APPENDIX I

Water Conservation and Supply Measures

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COST EFFECTIVENESS OF WATER CONSERVATION MEASURES

This portion of Appendix I discusses the costs, cost savings, and water use reductions that determine the economic effectiveness of the conservation measures discussed in Chapter V of the LWC Background Document. A key measure used in this discussion is cost effectiveness. Cost effectiveness is a comparative measure reflecting both the dollar costs (and dollar savings) of actions taken to achieve conservation goals and the water use reductions that result. The cost effectiveness of a measure can be defined as the net change in the costs that result from its implementation divided by the reduction in water use achieved while maintaining the same level of satisfaction.

The primary goal of water conservation is the reduction of water use. Water use is of concern to water managers both as a withdrawal and as a consumptive use. Consumptive use takes into account not only the withdrawal of water from the source (aquifer or surface water body) but the extent to which control of its future use is lost as it enters some other stage of the hydrologic cycle or system. Water that is applied for irrigation and adds to evapotranspiration is consumptive use. For all practical purposes, water discharged to tide is also consumptive use. Withdrawals, on the other hand, are the total water taken from the source. Withdrawals include both those parts lost and those which return to the original source or another reasonably usable source. The effectiveness measure most often considered for the conservation measures discussed in this appendix is water withdrawal. Determining the extent to which the withdrawals result in recharge or consumptive use requires detailed site-specific hydrologic testing and modeling, which is not feasible for this analysis. It is still important, however, in some cases to pay attention to whether the withdrawals generally result in consumptive use. For instance, irrigation withdrawals from the lower Tamiami aquifer in the Bonita Springs area are more significant when recharge rates from the water table aquifer are relatively low.

No conservation measure is equally cost effective in all applications. In fact, cost effectiveness is expected to vary greatly. Key factors affecting the cost effectiveness include the frugality of water use without the measures, the costs of the devices selected, their performance and reliability in providing desired services with reduced water use, and the costs of supplying water if the conservation measure had not been undertaken. A major focus of this section is to summarize the major conditions and cost factors which influence the cost effectiveness of conservation measures in particular applications.

Many of the conservation measures offer the possibility that, over time and for selected applications, the cumulative savings will exceed the costs. These conservation applications offer economic advantages over others that may entail additional costs, while still being less costly than available supply augmentation measures. For this reason a special term "cost saving" is used to describe the importance of these conservation measures.

Mandatory Water Conservation Measures

Water Utilities

Adoption of an Irrigation Hours Ordinance. The water use impacts of restricting allowable irrigation hours will depend on the changes in scheduling that users undertake. Users who merely switch the hours of operation of their irrigation systems and do not change the amount of time the systems are run will in effect be applying a little more water to the landscape. This will most likely increase the average soil moisture thereby increasing local recharge during minor rainfall events and runoff during major rainfall events. It may also increase the evapotranspiration (ET) off the landscape if the area is presently under irrigated. Users who reduce the time the systems are on or the number of days they are operated will be reducing withdrawals from the source. It has been estimated that switching the hours might increase the efficiency of application by 10 percent (conversation 1990 with Alan Smajstrla, Agricultural Engineering Department, University of Florida, Gainesville, FL). The use of manually controlled irrigation systems may be reduced because of the inconvenience of non-daylight operation.

Small costs are expected to result from the imposition of these requirements. Those with irrigation system timers may need to adjust the time of operation. Some effort will be required of those without timers and without in-ground sprinkler systems as they will most likely perform those jobs during the limited morning or evening daylight hours. In South Florida, the early morning is the best time to irrigate because disease problems are avoided and the vegetation is better prepared for daylight.

Adoption of a Xeriscape Landscape Ordinance. Water use savings from implementing Xeriscape landscape codes will result from reductions in irrigation water applied. The main factors influencing the cost effectiveness of Xeriscape landscape codes include the initial landscaping costs, irrigation costs, and maintenance requirements.

Landscaping Costs. The primary direct cost relating to a Xeriscape code is that for the initial landscaping, especially when it is installed by a professional landscape contractor. When a Xeriscape code is in effect, very drought-tolerant plants, such as ground covers or drought-tolerant grasses, may substitute in a portion (about 30 percent) of the landscape for the grass presently used (mostly standard St. Augustine varieties). An estimate of the installed cost of sod is $.17 per square foot. Ground covers generally cost more to install. Estimates of installed cost range from $.55 to $1.00 per square foot; however costs may be reduced by increased spacing between plants. Bahia costs about the same as conventional St. Augustine grass. Costs for the FX-10 drought-tolerant St. Augustine variety of turfgrass are higher than those for the other grasses. The difference in the installation costs of ground covers versus turf could amount to between $570 and $1,245 for a single-family residence with 5,000 square feet of total landscaped area when an additional 30 percent of the area is landscaped in ground cover instead of turf. It is important to note that very limited or no installation costs would be associated with preserved natural areas and that the area where the groundcover is installed may not require an irrigation system.

Irrigation Costs and Maintenance Requirements. In most areas, the costs for obtaining additional water for irrigation are low, so that for example, when $1.50 per 1000 gallons is charged by the utility to the customer, the expected reduction in watering costs will do little to equalize the costs between the turf and the drought-tolerant ground cover installations. Since the operating costs of individual wells and surface water intakes is smaller ($0.10 to $0.15 per thousand gallons), users of well water will save less by reducing water use than users of utility water.

Maintenance requirements for the different types of grasses are expected to be about the same as long as they are maintained to standards acceptable for urban landscapes. Maintenance efforts and costs for the ground cover are expected to be somewhat lower because they require periodic weeding and pruning about 4 times a year instead of mowing about 36 times a year. Some analyses indicate that large savings in maintenance costs will be achieved as a result of Xeriscaping. These analyses are often those that show large overall cost savings from Xeriscape.

The extent to which Xeriscape will reduce the costs of building new facilities to supply irrigated water will depend on the extent to which peak period water demands are reduced. Where utility supplied water is used for irrigation, peak utility demands typically occur in periods of high irrigation water use. By reducing water use in peak demand periods, utility plant expansions to meet these peak demands can be delayed. The effectiveness of Xeriscape in reducing these peaks, in turn, depends on the ability of the selected plants to tolerate reduced irrigation during droughts. Preserved on-site natural areas will have no need for irrigation and suffer little or no damage during extended periods of no rainfall. Where utility water is used for irrigation, the "no irrigation" areas will reduce the peak demands on the utility. For those self-supplied users with "no irrigation" areas, withdrawals would still remain low during periods when the Surficial Aquifer System is experiencing the least recharge and greatest potential for drawdown.

Adoption of an Ultra-Low Volume Fixture Ordinance. District estimates show that changing to the ULV fixtures from low-volume fixtures will save approximately 15 gallons per capita per day for residents of new housing structures. Almost all the savings would mean reductions in utility wellfield withdrawals.

The costs incurred will include the difference in the purchase and installation costs of the ULV fixtures versus the low-volume fixtures. However, these costs are offset by the savings in water and sewer costs. The savings in shower and faucet use have the additional benefit of saving water heating costs.

The key to the cost effectiveness of this alternative is that there not be a significant differential in the costs, operational life, and performance of the ultra-low volume versus the low-volume devices. Available data indicate that for devices with similar construction and use patterns, the ULV devices provide significant operating cost savings, and have payback periods of less than seven years for toilets, and even less for devices which save water heating costs.

Installation of ULV faucets and showerheads is generally cost saving. The cost effectiveness depends upon: (a) the cost of heating water; (b) the cost of water and sewer; (c) the utility discount rate; and (d) the number of persons per household, which is related to the intensity of use.

The most important factors influencing the cost effectiveness of ultra-low volume toilets are: (a) the relative cost of ULV and conventional toilets; (b) the cost of water and sewer; and (c) the intensity of toilet use, which is determined by the interaction of the number of people per household, the number of flushes per person per day, and the number of toilets per household. In part because of the relatively high cost of toilets, the degree to which the ULV toilets will be cost saving is less clear than in the case of faucets. Public restrooms, where the number of flushes per toilet per day is larger than in the typical home, offer one setting where ULV toilets can be effectively utilized. The payback period for ULV toilets is almost always longer than the payback period for ultra-low flow faucets.

Adoption of a Conservation Rate Structure. Successful implementation of a water conservation rate structure is reflected in reduced withdrawals at the utility wellfield. The responsiveness of the customers to the conservation rate structure depends on the existing price structure, the water conservation incentives of the new price structure, and the customer base and their water uses. Implementation of other water conservation measures such as Xeriscape, in conjunction with the conservation rate structure increases the effectiveness of this measure since users would be provided with a vehicle to achieve reductions in water use.

A model developed by Brown and Caldwell Consulting Engineers for the District estimated that a $1.00 increase in price per thousand gallons is expected to result in an 8 percent decline in indoor single-family residential (SFR) water use, and a 31 percent decline in SFR outdoor water use. This model shows the demand for water in the aggregate being relatively inelastic, which implies that relatively large increases in price may be necessary to achieve targeted levels of demand reduction. This relatively inelastic demand is consistent with values reported in the literature (Maddaus, 1987).

All utilities have the ability to use rate structures to guide customers in selecting water consumption levels and practices. A water conservation rate structure also allows each customer the freedom to select the most appropriate measures for their needs. Adoption of rate structures should consider the long-term costs differentiated by the conditions of service (e.g., time, location, volume) as they affect costs. That is, rates should reflect both utility operating costs and the costs of capacity expansion needed to meet anticipated future demands over the planning horizon. Properly designed conservation rates should assure that the desired level of cost recovery is achieved based on the anticipated demand patterns associated with the conservation rates. In implementing this concept, it is important that a long-run perspective be adopted, since in the short run, operating costs typically decline as water use increases, particularly if no value is assigned to the raw water.

Adoption of a Utility Leak Detection and Repair Program. Factors affecting the cost effectiveness of leak detection and repair programs include the costs of auditing water use and locating leaks, the size and location of leaks, and the costs of obtaining and treating the water that leaks, and the costs of the repair itself. Water savings from utility leak detection and repair will depend on the extent of implementation. The water resource impacts of the leaks, and the benefits of their repair depend on the size of the leak relative to the location of the source. That is, greater water resource impacts occur when the leak is large and close to the source aquifer.

Leaks are part of each utility's base and peak demands, and they require the utility to have capacity at all times to meet the burdens imposed by this loss of water. The financial costs of ignoring the leak include both the capital and the operating costs to supply water for the leaks. Water audit and leak detection are carried out on a periodic basis by most utilities and on a continuing basis by larger utilities. These audits help quantify the unmetered uses, identify the locations of unauthorized hookups, and determine how large the leakage problems are, and where they are located in the system. The inventory of losses and their locations then is the basis for the scheduling of leak repairs.

Adoption of a Rain Sensor Device Ordinance. The cost of a rainfall sensor switch has been estimated at $25 to $30 if the homeowner installs the system, or approximately $60 if the homeowner has the device professionally installed. Tensiometers and other soil moisture sensors cost several times as much, but allow for better control of irrigation scheduling and greater water savings. Rain sensor devices, when used as a part of a systematic irrigation program, can be quite cost-effective.

Implementation of a Water Conservation Public Education Program. The costs of public information programs are the outlays by public or private agencies to develop and implement these programs. The impacts on water use and the benefits to the water resource will depend on the actual use changes that result from the public information campaign and the sources of water for those uses. It is difficult to estimate the water savings from this alternative. It tends to act in synergy with other alternatives and is particularly important in supporting retrofit and audit programs as well as encouraging behavioral changes.

Literature on water conservation indicates that public information programs can be expected to achieve approximately four to five percent water savings. Public information may play an important role in encouraging water conservation for short-term drought management purposes. However, the impact of public information programs tends to decline the longer the public is asked to conserve water.

Analysis of Reclaimed Water Feasibility. An analysis of the economic, environmental and technical feasibility of making reclaimed water available is a required component of each utility water conservation plan. The wastewater utility capsules presented in Appendix E indicate that, with a few exceptions, the existing disposal plans of wastewater utilities in the LWC Planning Area include reuse of a large portion of available water. The required feasibility study should determine if additional reuse is economically feasible. Additional reuse may include transmission to areas where there are unmet demands that reclaimed water could meet; the use of percolation ponds, especially in locations where wellfields may benefit from the ground water recharge; and additional residential reuse. Studies of the costs of achieving high percentages of reuse show that the costs of adding to existing systems may vary from around $1.15 to $1.60 per thousand gallons. Implementing reclaimed water systems also saves the wastewater utility the cost of disposing of the water by other means and saves the user the cost of supplying water by alternative means. Also, the use of reclaimed water that offsets the use of potable water could forestall the need for costly water treatment plant expansion. An advantage to the user of reclaimed water is that its use is not restricted during declared water shortages. These advantages and cost savings have contributed to the widespread implementation of reuse by wastewater utilities and water users in the LWC Planning Area.

Commercial/Industrial Users

District regulations are formulated so that only those water conservation measures which the applicant finds to be cost-effective are required. Although it is difficult to generalize about the cost effectiveness of mandatory commercial/industrial conservation measures due to the wide variety of uses covered, a study by Ploeser *et al.* (1992) shows major types of commercial/industrial facilities which have significant potential for cost-effective conservation. These facilities and their range of observed percentage reductions include:

(a) Hospitals (13% to 42%);
(b) Schools (21%);
(c) Hotels (13% to 30%);
(d) Commercial - office buildings (16% to 45%);
(e) Beverage processors) (11% to 21%);

(f) Metal finishers - pc board manufacturers (15%);
(g) Commercial laundry (29% to 39%); and
(h) Food processors (15% to 30%).

"Businesses, industries, institutions and other large nonresidential water users often have the potential for meaningful water conservation. In recognition of this finding, a number of water utilities have instituted programs to promote water conservation by customers who use large volumes of water. In many cases, the customers themselves have recognized that water conservation is cost-effective and that implementing conservation actions is an investment in efficient plant operations. . . . As the cost of water increases . . . it is likely that more conservation actions will become cost-effective and therefore implementable." Furthermore, "water conservation by industry can result in reduced consumption and cost savings in other resources as well, including wastewater treatment, energy, and chemicals" (Ploeser *et al.*, 1992).

Landscape and Golf Course Users

Landscape and golf course permittees are required to use Xeriscape landscaping principles for new projects and modifications when they find this to be of significant benefit as a conservation measure relative to its cost. They are also required to install rain sensor devices or switches and to abide by the prohibition of irrigation between the hours of 10:00 A.M. and 4:00 P.M.

Many of the effects of provisions related to Xeriscape requirements on individual landscape and golf course permittees are similar to the effects of the Xeriscape ordinance on water utilities. Few adverse effects are expected because of the provision that Xeriscape landscaping provisions are only required when they are found to be to be of significant benefit as a conservation measure relative to their cost. Because of the large amounts of water used by landscape and golf course users, potential water savings are significant. Major factors affecting the cost effectiveness of landscape and golf course conservation measures include: (1) present sources of irrigation water and availability of alternative water sources, including reuse water; and (2) efficiency of existing irrigation systems and management practices. The flexibility of the Xeriscape requirement allows it to be imposed without resulting in significant adverse economic impacts on the regulated community.

The cost effectiveness of adopting rainfall sensor and irrigation hours ordinances by landscape and golf course users is similar to the cost effectiveness of adopting these measures by water utilities. These measures were previously discussed under the mandatory water conservation measures for water utilities.

Agricultural Users

Most new citrus acreage in the LWC Planning Area planted in the recent past has used micro irrigation, even in the absence of the mandatory conservation requirement. Nursery water users, however will face higher costs in complying with the new standard. University of Florida personnel who work with the nursery industry indicate that "trickle irrigation is currently limited in nursery situations to field-grown stock and large container stock, i.e., 5-gallon and larger" (Knox, 1989). Another factor increasing the costs of compliance with the nursery standard is that freeze protection requirements are not met by nursery low-volume systems. In many cases an overhead irrigation system will need to be constructed to provide supplemental freeze protection. Container nurseries utilize land intensively;

therefore potential losses associated with freezes pose a high risk, which many growers will not be willing to accept. These same intensity factors mean that potential losses from inadequate availability of water during drought are high.

The initial system costs for newly installed micro irrigation systems have been estimated at $5,500 for woody container nurseries, $6,500 per acre for potted foliage nurseries, and $40,000 per acre for bedding plants (SFWMD, 1993). Due to the need for supplemental freeze protection, container nurseries must often add the cost of an overhead or other high-volume system to their irrigation system costs.

Supplementary Water Conservation Measures

Residential and Commercial Users

Indoor Audit and Retrofit Measures. The residential audit will ultimately reduce the demands on the source supplying water to the users. In most cases, this source will be a utility, although the water may also be self supplied. Since the reductions in indoor use and leaks will provide constant reductions in demand, the peak as well as the base demands will both be reduced. Savings apart from those generated through device installations will result from leak repair and behavioral changes.

Preliminary analyses indicate that retrofit programs for significant portions of the population in existing housing would be cost saving. These programs would reduce water heating and wastewater treatment costs by an amount greater than the costs of the retrofit programs and devices. A high degree of cost savings can be obtained by targeting customers of utilities facing the need to expand capacity; customers having the older higher water use devices; and users with two or more persons using the retrofitted devices. Partial retrofit of the most heavily used facilities can increase the cost effectiveness of an audit and retrofit program.

The costs of implementation will depend on the devices chosen for retrofit and the methods of installation. Retrofit efforts which choose quality devices and professional installation are the most expensive, but may be offset by greater customer participation, water savings, and life of use reductions. The cost savings will depend on the reduction in economic resources needed to supply and heat the water, and treat the wastewater. Life-cycle spreadsheet analyses of the professional installation of ULV devices show that as long as there are two or more people using the retrofit device, there will be a savings until the end of the its useful life. Due to the volumes involved, a well-organized retrofit program should be able to offer lower costs in the purchase and installation of the devices.

The magnitude of savings from using low-flow showerheads and devices depends on (a) the cost of heating water; (b) the cost of water and sewer; (c) the utility discount rate; and (d) the number of persons per household, which is related to the intensity of use. The timing of the retrofit (i.e., useful life remaining in the device to be replaced) is an important factor in determining the cost effectiveness of low volume devices.

The primary factors which influence the cost effectiveness of retrofit toilets are relative cost of ULV and conventional toilets, cost of water and sewer, and the intensity of toilet use. Because of the higher capital costs associated with toilets, the timing of the retrofit program is important in determining the ability of the retrofit program to be cost saving. In general, retrofit is most cost effective when most of the useful life of the existing toilet has been exhausted. Toilets are more sensitive in this respect than are faucets and showerheads because of the higher capital cost and the longer useful life of the devices.

Savings per capita per day for each person using ULV devices, including toilets, instead of low-volume devices will be the same as for the ordinance alternative, about 15 gallons per capita day (GPCD). Savings when high-volume (pre-1980) toilets are replaced with ULV models would increase to about 20 GPCD. Because of the rapid growth in the LWC Planning Area, pre-1980 toilets make up a relatively small share of the toilets. Since domestic indoor uses are continuing at a constant rate, retrofits will affect demands during peak and off-peak demand periods.

Landscape Audit and Retrofit Measures. Factors affecting the cost effectiveness of landscape audit and retrofit measures include irrigation scheduling, audit costs, water costs, and the costs of purchasing, installing, and maintaining retrofit devices.

Probably the largest immediate water use savings from the landscape audit would be derived from improved scheduling of irrigations. The amount of potential improvement will depend on the schedule previously followed. For instance, watering on a daily or bi-daily basis could result in annual applications of 90 to 100 inches. This depth of water is applied over the area of the irrigated landscape, so that the larger the area to which the landscape audit and retrofit measures are applied, the larger will be the savings measured in gallons. If the landscape irrigator agrees to operate the irrigation system manually based on observation of the need for irrigation, then the irrigation could be reduced to 20 to 30 inches per year. Relying on a schedule that approximates evapotranspiration replacement would not require any observation of lawn conditions and would result in applications of about 60 inches. Achieving a reduction from a high schedule (90 inches) to the more efficient schedule (60 inches) is in accord with the experience of a study in Hillsborough County (West Coast Regional Water Supply Authority, 1987) which showed reductions averaging 27 percent between residences with and without calibrated and properly scheduled irrigation systems.

As an individually oriented information measure, there are usually significant costs to carrying out the visits and audits themselves. The District estimates that it would cost about $45 to $55 per household for a landscape audit program that includes testing the water source for pressure and output rate, testing sprinkler heads for precipitation rate and coefficient of uniformity, setting irrigation zones for proper times and frequencies, and developing an irrigation schedule.

The most cost effective areas will be areas in which the cost of water is high, such as saltwater intrusion areas where irrigation with potable water is common. The landscape audit and retrofit measure is also an important method to get irrigators to adopt good scheduling practices and, if they are willing, to adopt a practice of irrigating based on observed need.

The costs of this measure depend on the devices chosen for retrofit and the methods of installation. Choosing quality devices and professional installation are the most expensive implementation technique, but this may be offset by greater participation by the user, increased water savings, and longer lives of use reductions. At the present time, a rainfall sensor and switch costs about $25 to $30 retail. Professional installation costs about the same, bringing the total to about $60. Installation can be combined with a check of the irrigation clock to see that it is properly functioning and reasonably scheduled. The reduced irrigation saves on irrigation pumping costs or water costs if utility water is used.

Most of the irrigation water saved comes from individual wells and surface intakes. The estimated cost of applying water in this way is $0.10 to $0.15 per thousand gallons. Utility water cost savings, if potable water were the source, would be about $0.50 to $1.00 per thousand gallons. Using a conservative reduction in water application of 6 to 8 inches per year, the water cost saving would be about $0.56 to $0.75 per thousand square feet per year for individually supplied water and $1.87 to $4.99 per thousand square feet per year for utility supplied water. Since rainfall will be reasonably consistent over the area covered by a single irrigation system clock, only one rainfall sensor/switch should be needed per system. The effectiveness of the device, then, depends on the area covered by the switch. Using a 20 percent capital cost recovery factor for the rainfall sensor switch, the device could be cost saving for systems controlling more than about 18,000 square feet when self-supplied water is used and about 3,500 square feet when utility water is used. This indicates that these devices are cost effective for most existing landscapes of a size that are professionally managed and for homeowner sized areas using utility water.

Water Utilities

Utility Filter Backwash Recycling. This measure involves returning filter backwash to the water treatment facility for retreatment versus disposing of it in a pond. Recycling backwash water decreases raw water withdrawals. Disposing of this water in a pond may provide aquifer recharge, depending on the geology. Savings are achieved in that less raw water has to be pumped. Additional costs may be incurred for equipment to route the backwash to the head of the treatment plant.

This alternative is appropriate for evaluation of its cost effectiveness by water utilities in the LWC Planning Area when they prepare their conservation plans.

Utility Pressure Control. Utility pressure control affects the rate of withdrawal from the utility's water sources. Pressure differences will be greatest during periods of high demand in systems incapable of balancing pressures. The potential water savings from this measure will be highly specific to the utility involved. A 1984 U.S. Department of Housing and Urban Development report summarized the experience of previous evaluations of this measure. The summaries showed that a three to six percent reduction in water use was associated with a reduction of 30 to 40 psi in water pressure to selected areas in which residential water use was closely monitored. Irrigation is believed to have been a small part of residential use in those areas.

The costs incurred to implement this water conservation measure include the costs of data collection and engineering studies to determine the appropriate system adjustments, and the costs of the improvements including pipelines and valves. The savings would be the reduction in the capital and operating costs of the utility systems. Again, the costs will depend heavily on the specific configuration of each utility's system and the extent to which the utility has already taken advantage of the most cost-effective options.

This alternative is appropriate for evaluation with regard to cost effectiveness when utilities in the LWC Planning Area prepare their conservation plans. The focus of their analysis should be on pressure relief in areas experiencing abnormally high pressures.

Wastewater Utility Infiltration Detection and Repair. Infiltration depends on the outside water pressure relative to that inside the sewage collection pipes. Since ground water levels are highest during wet conditions, the infiltration rates also tend to be highest during wet periods. Thus, infiltration contributes most heavily to peak demands and will require that the utility have capacity to meet those burdens. Wastewater utilities have the greatest incentive to detect and stop infiltration when they are reaching the capacity of their treatment and disposal systems.

This alternative needs further evaluation to more accurately determine its potential and the cost effectiveness of efforts to reduce such inflows.

Agricultural Users

Irrigation Audit and Improved Scheduling. Irrigation audits and improved scheduling are ways to increase the efficiency of an irrigation system without making major modifications to the system's physical layout. Improved scheduling can be done with existing equipment through soil moisture budgets or by using soil moisture sensors. Improved scheduling alters the amount of water applied to better reflect the water content of the soil and the water requirements of the crop.

Because irrigation scheduling practices are site specific and dependent on rainfall patterns, it is difficult to estimate potential water savings from improved irrigation scheduling. For pumped irrigation systems, such as are common in the LWC Planning Area, the energy cost associated with pumping water is a significant consideration in selecting cost-effective irrigation systems and management practices. As water becomes increasingly scarce and energy costs rise, the importance of proper irrigation scheduling is likely to increase.

Irrigation audits are encouraged for all agricultural irrigation systems. Based on data assembled by the District, irrigation audits, and the implementation of the irrigation schedule recommendations, have been shown to significantly reduce water use.

Micro Irrigation Systems. The system efficiency of micro irrigation systems is estimated to be about 85 percent, while the system efficiency of seepage irrigation is about 50 percent. However, the realized efficiency of seepage is highly variable depending on a variety of site-specific factors. In the field, micro irrigation would use about 58 percent of the water that seepage irrigation uses, all other factors remaining the same. At present, use of high efficiency systems is mandatory only for new citrus and container irrigation system installations. This section discusses the water savings potential and the costs for retrofitting existing farms with micro irrigation systems. The discussion below summarizes water savings attainable for Collier, Hendry, and Lee counties.

Collier County. Agricultural water use accounts for 68 percent of the water demand in Collier County, and this percentage is projected to decrease slightly to 63 percent by the year 2010. There has been significant incorporation of micro irrigation systems, which have a potentially high application efficiency, into citrus production. However, use of high efficiency systems is limited for vegetable production in Collier County.

Hendry County Area. Agricultural water use accounts for 98 percent of the water demand in the Hendry County Area. In 1990, irrigation requirements for citrus made up 43 percent of the total agricultural demand, and this is projected to increase to 54 percent by 2010. Micro irrigation systems, which have a potentially high application efficiency, have been incorporated into new citrus production. The magnitude of water demand for citrus irrigation is such that even small percentages saved will result in significant decreases in demand. Use of high-efficiency systems is limited for the other crops grown in Hendry County.

Lee County. Agricultural water use accounts for 34 percent of the water demand in Lee County, and this percentage is forecast to decline to 26 percent by the year 2010. Although agriculture uses less water than urban areas in Lee County, there is still a significant amount of water to be saved in agriculture. As in Collier and Hendry counties, major potential savings beyond the irrigation audit and the mandatory adoption of low-volume irrigation systems is the promotion of semi-closed irrigation systems for vegetable production.

Whether or not a switch to micro irrigation systems will prove financially attractive to farmers depends on the net effect on profits of adopting production systems that incorporate efficient irrigation systems. To date, most citrus growers have adopted production systems based on efficient irrigation. On the other hand, vegetable growers and container nurseries have been slow to adopt these efficient systems, which indicate problems with the costs and/or revenues.

REGULATIONS AND SUPPLEMENTAL INFORMATION FOR WATER SUPPLY ALTERNATIVES

The state's environmental regulation agency, the Florida Department of Environmental Protection (FDEP), regulates the two water supply alternatives discussed in this section, wastewater reuse and aquifer storage and recovery. The FDEP was formerly the Florida Department of Environmental Resources (FDER). In July 1993, the FDER was merged with the Florida Department of Natural Resources (FDNR) to form the Florida Department of Environmental Protection (FDEP). This appendix refers to the FDEP even when the data was collected prior to the merger.

Wastewater Reuse

Reuse is the deliberate application of reclaimed water for a beneficial purpose in compliance with the FDEP and Water Management Districts rules. Reclaimed water is wastewater that has received at least secondary treatment and is reused after flowing out of a wastewater treatment plant (Chapter 17-610, F.A.C.). Reuse includes:

- Landscape irrigation (such as irrigation of golf courses, cemeteries, highway medians, parks, playgrounds, school yards, retail nurseries and residential properties).
- Agricultural irrigation (such as irrigation of food, fiber, fodder and seed crops, wholesale nurseries, sod farms, and pastures)
- Aesthetic uses (such as decorative ponds and fountains)
- Ground water recharge (such as slow rate and rapid rate land application systems)
- Industrial uses (such as cooling water, process water and wash waters)
- Environmental enhancement (such as wetlands restoration)
- Fire protection

The FDEP 1992 Reuse Inventory identified 308 wastewater treatment facilities ($\geq$ .10 MGD) that are reusing approximately 290 MGD of reclaimed water in Florida. These facilities have a permitted design capacity for reuse of 601 MGD. This is a substantial increase from the 1990 Reuse Inventory, which identified 199 wastewater treatment facilities that were reusing approximately 266 MGD of reclaimed water (FDEP, 1990). Among the many reasons for the increased utilization of reuse are: (1) it is an environmentally acceptable means of disposal; (2) state regulations have been adopted; (3) there is an increased public acceptance; and (4) the frequency of drought and water restrictions have increased. Treated wastewater, when properly treated to acceptable standards for the reuse, is no longer a waste but a valuable nonpotable water resource which will enhance the regional water inventory. Reclaimed water is and will continue to have a substantial role in water supply in Florida.

Reuse in the Planning Area

Sixteen of the regional wastewater facilities in the LWC Planning Area utilized reuse for reclaimed water disposal in 1990. The methods of reuse employed by these facilities included ground water recharge via percolation ponds, public access spray irrigation of golf courses, residential lots and other green space, and restricted public access spray irrigation of hay fields. The facilities utilizing reuse for all or part of their disposal needs are listed in Table I-1.

TABLE I-1. Lower West Coast Planning Area 1990 Reuse Facilities.

Facility	Public Access Spray Irrigation			Percolation Ponds	Spray Fields
	Golf Course	Residential Lots	Green Space		
Collier County					
Collier County North	X			X	
Collier County South	X			X	
FL Cities Golden Gate				X	
Immokalee					X
Marco Island	X			X	
Naples	X		X		
Pelican Bay	X	X	X		
Hendry County					
Clewiston					X
Lee County					
Bonita Springs	X	X	X		
FL Cities Fiesta Villages	X				
Forest Utilities	X				
Fort Myers Beach	X		X	X	
Gateway				X	
Lehigh Utilities				X	
North Fort Myers	X				
Sanibel Island	X			X	

Many of the treatment facilities utilized reclaimed water for plant process water and for irrigation of the plant site, which also could be considered reuse. Reuse of 19.08 MGD of reclaimed water in 1990, accounted for 46 percent of the total wastewater processed in 1990 in the LWC Planning Area. The remaining 22.68 MGD was disposed of by deep well injection or discharge to surface water and lost from the water supply inventory. This water, that was disposed of by deep well injection and discharge to surface water, could have been made available with the addition of regulatory mandated equipment including filtration and the associated chemical feed system, disinfection facilities and reclaimed water monitoring equipment. A required facility reliability of Class I, or an equivalent may exist via their existing method of disposal. In some cases, the existing method of disposal may also be utilized as an alternate means of disposal during periods of low demand or when the required reclaimed water quality is not met, which may negate the need for regulatory mandated storage.

Many of the facilities listed in Table I-1 will continue to increase their amount of reuse when additional reclaimed water becomes available and/or when demand is created. In addition to these facilities, the City of Cape Coral completed and initiated operation of their Water Independence for Cape Coral (WICC) program in early 1992. This program provides reclaimed water, supplemented with canal water, for public access spray irrigation on residential lawns and other green space. Approximately 10,000 properties have been connected to the system. Also, a 2.00 MGD reuse facility at the Fort Myers Central Facility is under design. Initial use includes 1.00 MGD for cooling water at the resource recovery facility, and irrigation of the city nursery, the Fort Myers cemetery, ball fields, and others. Utility-specific information is provided in Appendix E.

Florida's Comprehensive Reuse Program

The State and District objectives include promoting and encouraging water conservation and reuse of reclaimed water. To achieve these objectives, several requirements and regulations have been implemented as part of a comprehensive reuse program. These are: (1) Chapter 17-40, F.A.C., (2) Section 403.064, F.S., (3) the FDEP's Antidegradation Policy, (4) guidelines for preparation of reuse feasibility studies, (5) SFWMD Basis of Review, and (6) State reuse regulations.

Chapter 17-40, F.A.C. This chapter, also referred to as the State Water Policy, requires the water management districts to designate areas that have water supply problems which have become critical or are anticipated to become critical within the next 20 years. This chapter further states that a reasonable amount of reuse shall be required within these areas. The SFWMD adopted the designated critical water supply problem areas by rule (Chapter 40E-23, F.A.C.) in October of 1991. The Lower West Coast Planning Area is incorporated in this designation.

Section 403.064, Florida Statutes. This section of the statutes requires all applicants for domestic wastewater permits from the FDEP for facilities located in a critical water supply problem area to evaluate the feasibility of reuse of reclaimed water as part of their application for the permit.

FDEP Antidegradation Policy. This policy is contained in Chapter 17-4, F.A.C., "Permits," and Chapter 17-302, F.A.C., "Surface Water Quality Standards." Compliance with the state's antidegradation policy must be justified prior to issuance of a permit by FDEP for any new or expanded surface water discharge. The antidegradation policy requires a utility proposing to construct a new discharge or expansion of an existing discharge, to demonstrate that an alternative disposal method such as reuse of domestic reclaimed water is not feasible in lieu of a discharge to surface water, and that such a discharge is clearly in the public interest. This requirement is discussed further in Appendix E.

Reuse Feasibility Studies. There are several rules, statutes, or laws that require preparation of reuse feasibility studies. The FDEP, with assistance from the water management districts and the public service commission, have developed guidelines for preparation of reuse feasibility studies for applicants having responsibility for wastewater management to aid in coordination, consistency and completeness of these studies.

SFWMD Basis of Review. Revisions to the District's Basis of Review, adopted by the Governing Board in October 1992 and which became effective January 4, 1993, require feasibility evaluations of reuse. For all potable public water supply utilities who control, directly or indirectly, a wastewater treatment facility, an analysis of the economic, environmental and technical feasibility of making reclaimed water available shall be incorporated into their water conservation plan at the time of permit application.

Applicants for permits for commercial/industrial uses and agricultural, landscape, and golf course irrigation uses which are located in a critical water supply problem area are required to use reclaimed water in place of higher quality water sources, unless it is demonstrated that its use is either not environmentally, economically or technically feasible. Reclaimed water also has to be readily available for facilities located outside a designated critical water supply problem area.

State Reuse Regulations. The state adopted Chapter 17-610, F.A.C., "Reuse of Reclaimed Water and Land Application," in April of 1989. This Chapter contains the specific reuse and land application requirements of the FDEP and the Local Pollution Control programs where such authority has been delegated to those programs. The chapter is discussed in detail later in this section.

Reuse Benefits

Several benefits result from the use of reclaimed water for nonpotable water needs. When reclaimed water is utilized to replace a potable supply for nonpotable needs, the benefits include:

- Postponement or elimination of future water treatment plant expansions
- Postponement or elimination of construction of additional water supply wells
- Reduction in the size of the potable water distribution lines
- Reduction in monthly water bills

Additional benefits to the above and with respect to other ground water users are:

- Guaranteed source of water
- Reduced demand on the ground- or surface-water resource
- Exempt from water shortage/restriction requirements
- Reduced application of commercial fertilizers since reclaimed water contains nutrients
- More water available and reduced demands during water shortages for the regional water supplier
- Ground water recharge
- Satisfaction of antidegradation requirement for expansion of a surface water disposal facility
- Exempt from SFWMD permitting

Public Health

Health risks with reclaimed water are relative to the degree of human contact and adequacy/reliability of the treatment processes that produce the reclaimed water. The FDEP has developed reuse regulations that require extensive treatment and disinfection to assure that continuous and reliable supplies of high quality reclaimed water are produced to ensure that public health and environmental quality are protected. Each type of reuse is afforded an appropriate level of treatment and disinfection. In addition to extensive treatment requirements, several application site standards must be adhered to which also minimize potential health risks. The Florida Department of Health and Rehabilitative Services has concluded that a reuse facility designed, constructed, and operated to meet the requirements of the state's reuse rules poses no threat to public health (FDEP, 1990).

Regulatory Agencies and Requirements

Reclaimed water treatment, quality and use is regulated by the FDEP. The primary document utilized for regulation of reclaimed water and reuse is Chapter 17-610, F.A.C., "Reuse of Reclaimed Water and Land Application," which was promulgated on April 5, 1989. This chapter contains specific reuse and land application requirements of the FDEP and the Local Pollution Control Authority delegated programs providing design, operation and maintenance requirements for land application systems. Chapter 17-610 provides the requirements for reuse via (1) Slow-Rate Land Application Systems; Public Access Areas, Residential Irrigation, and Edible Crops; (2) Slow-Rate Land Application Systems; Restricted Public Access, and; (3) Rapid Rate Land Application Systems and Other Land Application Systems. The document specifies the level of treatment required for specific uses of the reclaimed water, the required reclaimed water monitoring equipment, the reliability of the treatment facility, the criteria for the land application system (i.e., golf course, percolation pond, etc.) and system operation. The specific requirements for slow-rate land application systems; public access areas; residential irrigation; and edible crops are located in Table I-2.

In addition to Chapter 17-610, F.A.C., the state has adopted the Wetlands Application Rule, Chapter 17-611, F.A.C., which establishes the foundation and criteria for wetlands receiving reclaimed water.

Reclaimed Water Distribution

Reclaimed water, that has received the required treatment, is delivered to individual users by a dual water system. A dual water system consists of two transmission systems/pipes: One delivers potable water for activities such as cooking, drinking and bathing. The other delivers reclaimed water for activities that do not require potable water, such as irrigation, car washing and industrial uses. Although the reclaimed water transmission system could be designed in several ways and configurations, it is generally one of three basic designs: (1) a low pressure transmission system, (2) a medium pressure transmission system with booster pumps, and (3) a high pressure transmission system. Storage requirements of the system would have to be developed on a case-by-case basis, depending on the design of the reclaimed water transmission system and the user's reclaimed water usage schedule. To prevent cross connection, reclaimed water pipes must be color coded or marked to differentiate reclaimed water from domestic or other water.

The low pressure transmission system consists of an open system which delivers reclaimed water at a low pressure 24 hours a day to the user's on-site storage facility (storage tank, pond, etc.). The reclaimed water is repumped by the user when needed. The reclaimed low pressure water transmission system is designed to meet the peak daily flow because the user's storage facility is filling continuously throughout the day. The operating pressure must be sufficient to deliver water to the user's storage facility for repumping. This system is best suited for large users such as a golf course or industrial facility with ponds or holding tanks to store the reclaimed water until it is needed.

The medium pressure transmission system, with booster pumps, is a closed system that delivers reclaimed water at a pressure which may be below the minimum pressure requirements of some of the users; the pressure is boosted to meet those user's needs on site. The reclaimed water transmission system is designed to meet peak hourly flows because reclaimed water should be available on demand. Pressure

TABLE I-2. Chapter 17-610, F.A.C. specific requirements for reuse of reclaimed water and land application for public access areas and edible crops.

Criteria	Requirements
Minimum System Size	- 0.10 MGD FDEP rated capacity for slow-rate application in public access areas - 0.50 MGD FDEP rated capacity for slow-rate land application on residential properties or edible crops; except for citrus, where the minimum system size can be reduced to 0.10 MGD if the reclaimed water does not contact the fruit, the fruit is processed before human consumption, and public access is restricted
Waste Treatment and Disinfection	<u>Advanced Secondary Treatment</u> - Carbonaceous Biochemical Oxygen Demand (CBOD) $\leq$ 20 mg/L - Total Suspended Solids (TSS) $\leq$ 5 mg/L - Filtration and chemical feed facilities required <u>High Level Disinfection</u> - No detectable fecal coliform 75 percent of the time with no one sample exceeding 25 colonies per 100 ml
Reliability	- Class I or an equivalent
Monitoring	- Continuous on-line monitoring for turbidity and disinfectant
Storage Requirements	- No storage required if another disposal system is incorporated into system design <u>System Storage</u> - Storage that would be required for a ten year recurrence interval and at a minimum, a volume equal to three times the design average daily flow of the reuse system. Golf course ponds are appropriate for reclaimed water system storage and storm water management provided all Department and District rules are met. - System storage ponds do not have to be lined. <u>Off-Line (Reject) Storage</u> - Minimum volume equal to one day at the average daily design flow
Setback Distances Application Site	- 75 feet from edge of wetted area to potable water supply wells - No setback distances to nonpotable water supply wells, surface waters, developed areas, private swimming pools, hot tubs, spas, saunas, picnic tables or barbecue pits
Hydraulic Loading Rates	- A maximum annual average loading rate of two inches per week is recommended
Monitoring of Ground Water	- A ground water monitoring program will have to be established for the system

range for the system is between 40-60 pounds per square inch (psi). This is sufficient pressure to operate most irrigation systems; however, this pressure would have to be boosted to meet the pressure needs of a golf course irrigation system.

The high pressure reclaimed water transmission system is a closed system which is directly connected to, and delivers reclaimed water to the user, at a necessary pressure, to operate the user's distribution (irrigation) system. The reclaimed water transmission system is designed to meet the peak hourly flow since reclaimed water should be available on demand. The system pressure would be approximately 80 psi or higher. Golf course irrigation systems require a pressure of at least 80 psi while residential and other irrigation systems require no greater than 40 psi. This system could include a multi-application reuse system for residential, golf course, park and any other green space irrigation that lacks sufficient space to construct on-site storage facilities.

Potential Uses

Florida's water policy states that water management programs shall seek to "encourage the use of water of the lowest acceptable quality for the purpose intended ... where economically and environmentally feasible." The District and State support reclaimed water as an appropriate alternate source for irrigation when reasonable and available. There are many uses of reclaimed water as identified previously. A discussion of each follows.

Golf Courses. One of the predominate methods of reuse in Florida is for large-scale irrigation, particularly irrigation of golf courses. Currently, there are approximately 141 golf courses in Florida utilizing reclaimed water for irrigation. In the LWC Planning Area, there are a total of 96 golf courses with a total irrigated acreage of 10,138 acres. The estimated average supplemental (irrigation) water requirements of the existing golf course acreage is 33.59 MGD. Thirty-eight of these courses utilize reclaimed water for all or a portion of their irrigation. The irrigated golf course acreage in the LWC Planning Area is projected to increase to 19,578 acres by the year 2010. The 2010 projected acreage will require an average supplemental irrigation of 65.15 MGD (see Appendix G for a detailed discussion of demand projections). The golf courses and wastewater treatment facilities in the LWC Planning Area are indicated in figures I-1 through I-3. The City of Naples and the Loxahatchee Environmental Control District (ENCON) are examples of golf course reuse systems.

The City of Naples wastewater treatment facility is an 8.50 MGD facility which provides reclaimed water for irrigation to nine golf courses as well as three sites for green space irrigation. In 1990, the irrigation sites utilized an average of 3.14 MGD of reclaimed water. Besides providing irrigation water, reuse provides Naples with an environmentally acceptable alternate disposal method to the existing surface water discharge pursuant to a FDEP no-discharge requirement. The reuse system significantly reduces the demand for ground water, which is one of the city's major sources of potable water (Marcello and Chaffee, 1988).

ENCON is a 6.54 MGD wastewater treatment facility located in Jupiter, Florida. They provide reclaimed water to nine golf courses in the Jupiter/Tequesta area via a 25 mile distribution network. Many golf courses in the area had drastic reductions in ground water allocations, and the treatment facility was seeking an environmentally accepted means of effluent disposal and a method to enhance the regional water inventory. The first golf course started receiving reclaimed water in 1984 and since

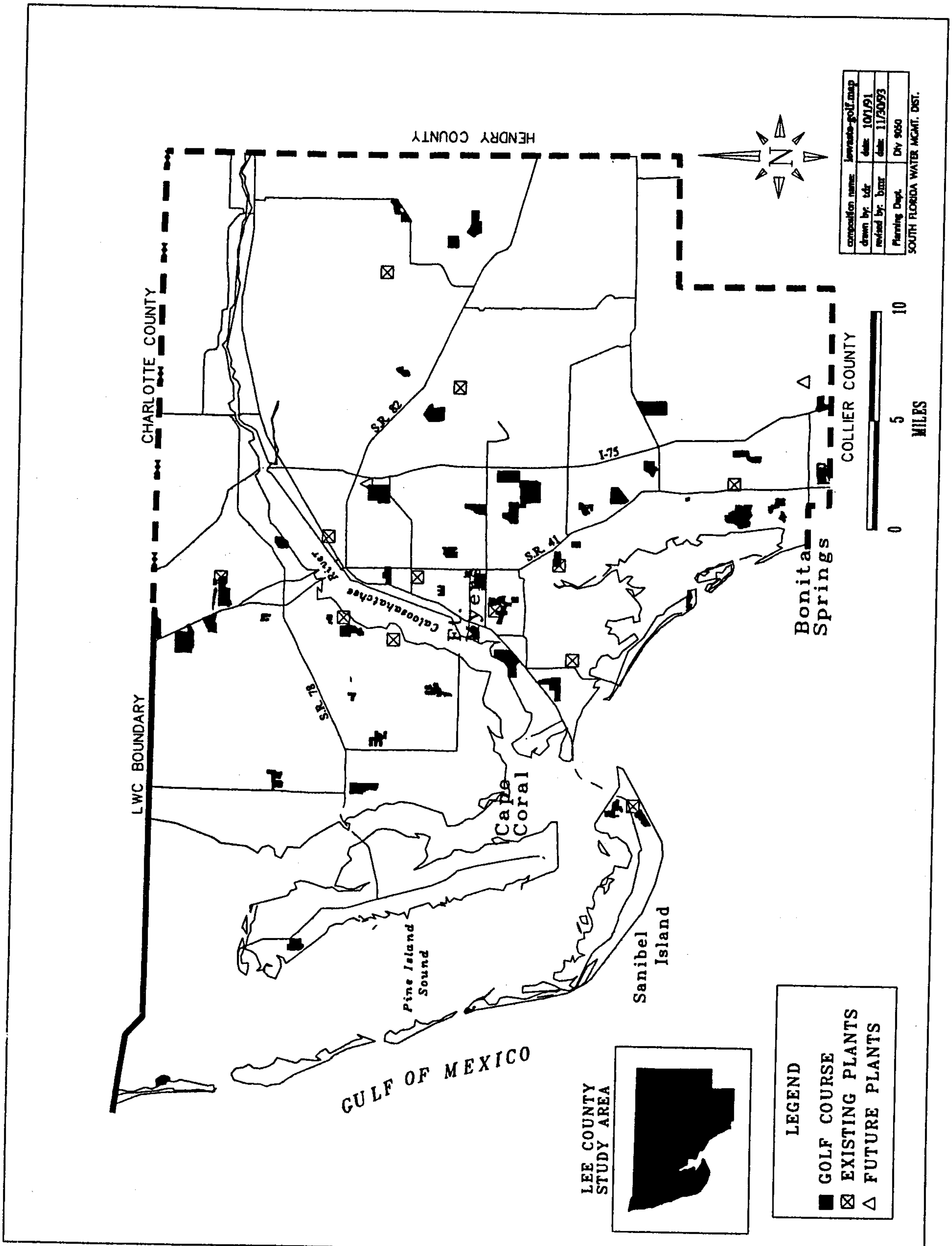

FIGURE I-1. Lee County Wastewater Treatment Plants and Golf Courses.

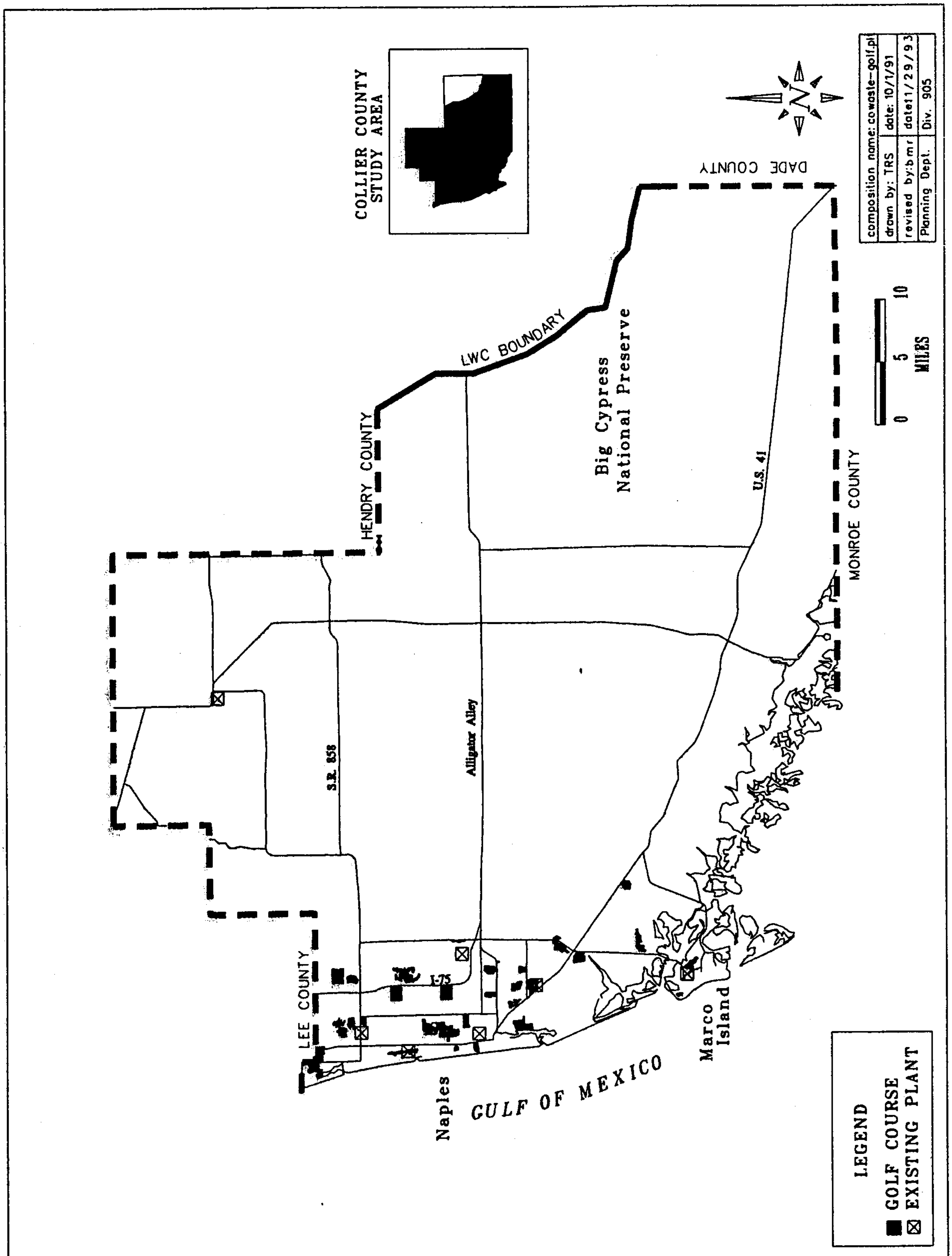

FIGURE I-2. Collier County Wastewater Treatment Plants and Golf Courses.

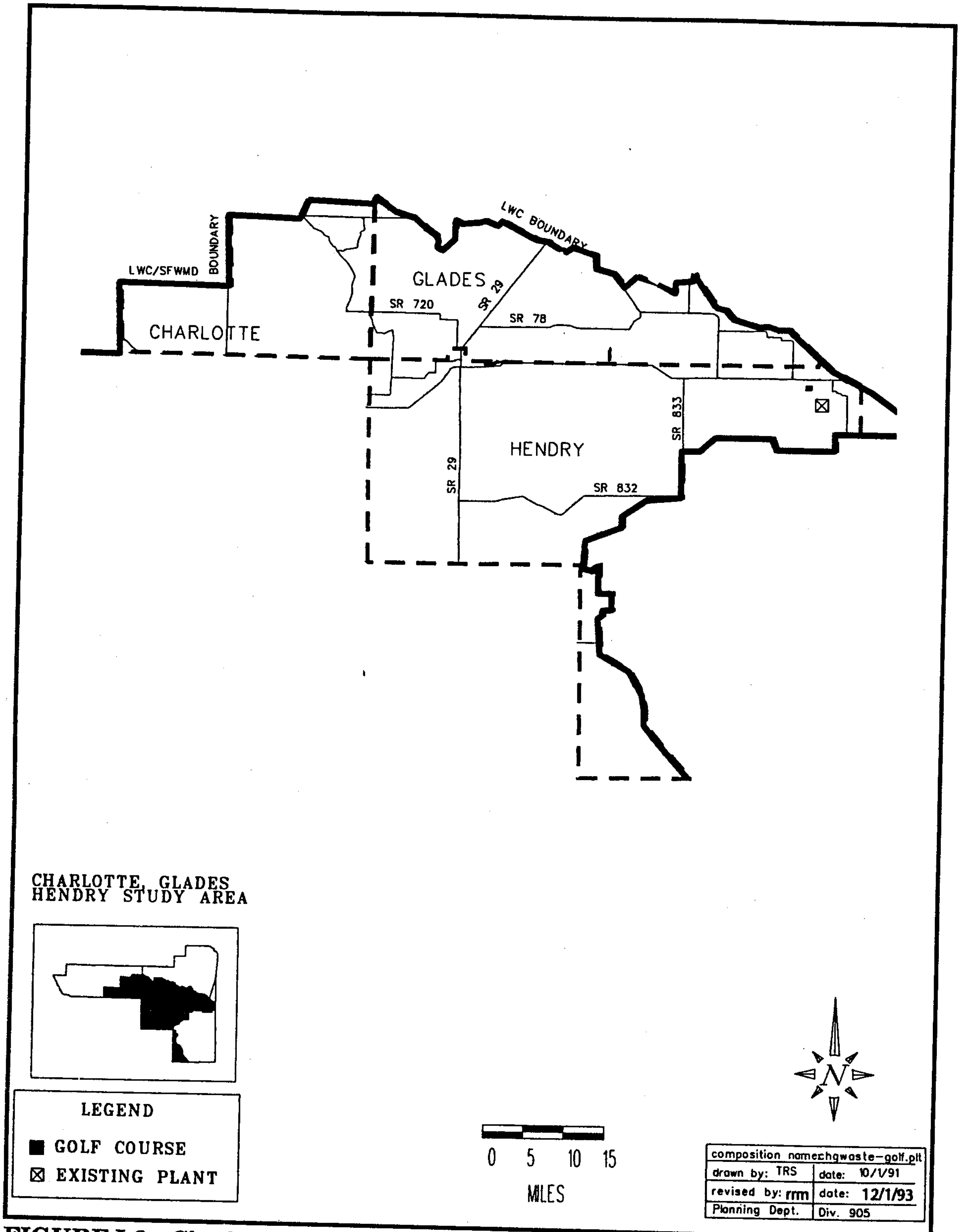

FIGURE I-3. Charlotte, Glades, and Hendry County Wastewater Treatment Plants and Golf Courses.

then, the response has been overwhelming to the concept (Dent and Davis, 1987). The facility is delivering approximately 4 MGD of reclaimed water to the reuse system.

Outdoor Residential. It is estimated that approximately 50 percent of the potable water delivered to single family homes is utilized for outside uses. This can amount to a considerable volume of water treated to potable standards. A substantial savings in potable water, and in turn ground water, could be realized by utilizing reclaimed water for these outdoor nonpotable water uses. These savings may eliminate the need for expansion of existing water treatment facilities, drilling of new wells, or reduce the need for new facilities. The benefit to the consumer in utilizing reclaimed water are lower monthly water bills, reduced need for fertilizer, and exclusion from water shortage restrictions. Several municipalities, including the cities of Naples and Fort Myers, have adopted ordinances that require new developments over 10 acres to install dual water distribution systems with the anticipation of reclaimed water becoming available in the future. Some Florida communities which have implemented, or which are proposing to implement, residential reclaimed water systems are Cape Coral, St. Petersburg, and Boca Raton.

The City of Cape Coral initiated operation of a system in early 1992 to provide reclaimed water for public access irrigation on residential lawns and other green space via a secondary water line as part of the Water Independence for Cape Coral (WICC) program. As part of WICC, reclaimed water and canal water is used are used as supply sources for the secondary system, which will be distributed throughout the city for residential lawn and other green space irrigation. Approximately 10,000 properties are connected to the system. The city will continue to connect additional users to the secondary system. A secondary water system demand of 36.80 MGD is projected in 1993 and 116 MGD at build-out.

St. Petersburg has one of the largest urban reuse irrigation systems in the nation. The program was initiated in the mid-to-late 1970s when the city recognized the need to reduce future potable water imports from adjoining counties. In addition, they were faced with required wastewater treatment facility upgrades because of more stringent water quality standards established for Tampa Bay. St. Petersburg was also declared a water short area (Eingold and Johnson, n.d.). Today, the reuse program consists of four treatment facilities with a total rated capacity of 68.4 MGD with approximately 240 miles of reclaimed water transmission main. Deep well injection systems serve as an alternate means of disposal for the reuse system. The reuse system currently serves 6,570 residential customers among other users. The average daily reclaimed water usage is approximately 21 MGD. It has been estimated that the reuse program in St. Petersburg has extended the capacity of their potable water treatment and supply system by 15 years (phone conversation March 26, 1991 with Joe Towery, Reuse Coordinator, City of St. Petersburg, FL.).

The City of Boca Raton is in the process of initiating "Project IRIS" or "In-city Reclamation Irrigation System." Project IRIS will be an extensive dual reclaimed water system throughout the eastern two-thirds of the city's service area. It is in this area that reuse will have the greatest impact on potable water consumption and reduction of saltwater intrusion. Boca Raton's 1989 potable water per capita consumption was well over 400 GPD. It was determined 70 percent (280 GPD) of consumption was for outdoor use. There are also several golf courses and other large users with wells for irrigation in this area. Elimination of these wells would also reduce the potential for saltwater intrusion of the freshwater aquifer. It is projected that the wastewater flow in the year 2000 will be 15 MGD, which will be sufficient to supply reclaimed water to the proposed service area. This daily reclaimed water demand will annually conserve three billion gallons of treated potable water and one billion gallons of untreated irrigation water presently withdrawn from the surficial aquifer. With timely implementation, the proposed reuse project will eliminate the need for a 10 MGD expansion of the water treatment plant and related water supply wells, thereby avoiding a capital expenditure of between $7.7 million and $8.7 million. Funding for the project is recommended to come from accumulated water conservation rate funds (Camp, Dresser & McKee, 1990).

Other Green Space. This category includes all other green space that requires supplemental irrigation where use of reclaimed water is desirable. This would include irrigation of parks, activity fields, schools, median strips, cemeteries, commercial landscapes, common areas, and retail nurseries. The development of Pelican Bay utilizes reclaimed water to supply their master irrigation system, which supplies irrigation water for residential lawns, median strips, common areas and other green space. In addition, Lee County's Fort Myers Beach facility provides reclaimed water to five developments for their green space irrigation needs.

Agriculture. Agricultural irrigation includes irrigation of food, fiber, fodder and seed crops, wholesale nurseries, sod farms, and pastures. State regulations prohibit direct contact of reclaimed water with edible crops that will not be peeled, skinned, cooked, or thermally processed before human consumption. However, if an indirect reclaimed water-application irrigation method is used (such as ridge and furrow, drip, or subsurface), precluding direct contact of the reclaimed water with the crop, irrigation is allowed. There are several agricultural operations that utilize reclaimed water for irrigation throughout the state, including sites in Tallahassee, Orlando, and Okeechobee and Manatee counties. Citrus, gladiolus, sod, ridge and furrow crops, ferns, hay, corn, soybeans, rye, oats and wholesale nursery plants are some of the crops presently being irrigated with reclaimed water. In 1990, the LWC Planning Area contained approximately 224,549 acres of irrigated agricultural lands. This is projected to increase to 341,047 acres by 2010.

The Conserv II water reclamation facility, located in Orange County, is jointly owned and utilized for reclaimed water disposal by both the City of Orlando and Orange County. Conserv II currently provides reclaimed water for irrigation of 7,000 acres of citrus and 10 acres of ferns plus ground water recharge via 2,000 acres of rapid infiltration basins. This site receives reclaimed water from the City of Orlando Sand Lake Road and Orange County McLeod Road wastewater treatment facilities with rated capacities of 21 MGD and 23 MGD, respectively. Conserv II has a capacity to irrigate 15,000 acres and dispose of 50 MGD (Metcalf & Eddy, n.d.).

Industrial. Potential industrial uses of reclaimed water include cooling, process and wash waters. Potential users include power plants, manufacturers such as metal fabricators and plating, cement makers, commercial and institutional facilities. Facilities in Hillsborough and Broward counties, Tampa and Largo use reclaimed water for industrial uses. In certain situations, reclaimed water is not fully consumed in some industrial processes. Proper disposal of this reclaimed water must be satisfactorily addressed. Two examples of industrial facilities that utilize reclaimed water are the North Broward resource recovery facility and the Curtis Stanton Energy Center.

The North Broward County resource recovery facility recently placed into operation utilizes approximately 2 MGD of reclaimed water from the Broward County North District wastewater treatment facility as cooling water. The used cooling water is returned for treatment when the quality decreases below the power plants specifications.

The coal fired Curtis Stanton Energy Center power plant in Orange County utilizes approximately 3.5 MGD of reclaimed water from the Orange County Eastern Service Area wastewater treatment facility for boiler cooling water.

Environmental Enhancement. Reclaimed water could be utilized for environmental enhancement in the restoration of hydrologically altered wetlands. There are several wetlands projects utilizing reclaimed water in Florida, two of which are the City of Orlando Iron Bridge and the Orange County Eastern Service Area wastewater treatment facilities.

The Orlando Iron Bridge Regional Water Pollution Control wastewater treatment facility utilizes a man-made wetlands system for reclaimed water disposal. The 1,200 acre created wetlands consist of a deep marsh, mixed marsh, and hardwood swamp. The current flow into the wetlands is limited to 13 MGD, but ultimately the wetland will receive up to 20 MGD of reclaimed water that has received advanced wastewater treatment. From the created wetlands, the reclaimed water flows through the 660 acre Seminole Ranch wetlands prior to discharge to the St. John's River. This system was placed into operation in 1987 (Schnelle and Ferraro, 1991).

The Orange County Eastern Service Area wastewater treatment facility utilizes an overland flow and wetlands system to currently dispose of 3.5 MGD of reclaimed water that has received advanced wastewater treatment. The wetlands system consists of 150 acres of natural wetlands and 150 acres of pine flatwood converted to wetlands which discharges to the Econlockhatchee River. The system will have an ultimate capacity of 6.2 MGD. This system was placed into operation in 1988.

Rapid Rate Land Application. Rapid rate land application involves discharging reclaimed water to a series of percolation ponds or subsurface absorption systems (drainfields). The FDEP requires, at a minimum, that reclaimed water receive secondary treatment and basic level disinfection prior to discharge to a rapid rate land application system. In addition, reclaimed water discharged to subsurface application systems must not contain total suspended solids greater than 10 mg/L. The application rate is limited to 5.6 gallons per day per square foot, unless greater loading rates are justified. There are many rapid rate land application systems in operation in the LWC Planning Area, mostly associated with reclaimed water disposal from small wastewater treatment plants. However, several large plants utilize rapid rate land application for their primary method of reclaimed water disposal or as a backup to another reuse system.

Hydrodynamic Saltwater Intrusion Barriers. Reclaimed water could be used for ground water recharge in areas of saltwater intrusion. This would be accomplished via rapid rate land application systems or by shallow injection wells. Rapid rate land application such as ponds or drainfields would be strategically placed to deter further migration of the saltwater front. This could be accomplished by constructing long trenches, percolation ponds or subsurface disposal systems parallel to the saltwater front. Injection of reclaimed water by shallow wells has been investigated on Florida's southeast coast. This method of reuse would consist of construction of several injection wells along the saltwater front, which when in operation, would create a positive freshwater head and impede further migration of the saltwater front inland. Injection of reclaimed water is heavily regulated by state and federal agencies. These agencies' regulations prohibit injection of fluids that do not meet applicable water quality standards. Florida Statutes prohibit the direct pumping of reclaimed water into any geologic formation of the Biscayne Aquifer containing less than 500 mg/L total dissolved solids (TDS). Depending on the local geology/geologic profile and the TDS of the formation fluid, various regulations and criteria apply (FDEP, 1990).

Aquifer Storage and Recovery

Regulatory Criteria

Current regulating criteria for ASR are divided into three categories: (1) untreated surface water permitting, (2) treated water permitting, and (3) aquifer-to-aquifer permitting. Proper clearance of an untreated surface water ASR project, as seen in Table I-3, includes up to six state and federal permits. Proper clearance of a treated water ASR project as seen in Table I-4 generally requires two permits from the SFWMD and FDEP. For a project that involves injecting untreated ground water from one aquifer into another aquifer, the permits identified in Table I-5 are required.

TABLE I-3. Permits Required for Untreated Surface Water ASR Projects.

Permit Type	Description	Issuing Agency
Well Construction Permit	Untreated surface water ASR must be in accordance with Class I well standards (state permit)	Florida Department of Environmental Protection
Dredge and Fill Permit	Permit needed if intake occurs from a surface water body (state and federal permits)	Florida Department of Environmental Protection and United States Army Corps of Engineers
Consumptive Water Use Permit	Permit needed for operation of untreated surface water ASR project (state permit)	South Florida Water Management District
National Pollution Disposal Elimination System (NPDES)	Permit needed if untreated surface water ASR project discharges to a surface water body (federal permit)	United States Environmental Protection Agency
Water Quality Criteria Exemption	Exemption needed if untreated surface water ASR project discharges to a surface water body (state permit)	Florida Department of Environmental Protection
Aquifer Exemption	Exemption needed if injected waters are nonpotable and the aquifer is classified as an underground source of drinking water (federal permit)	United States Environmental Protection Agency

Permitting for untreated surface water has only been done once in the southeastern United States, for the South Florida Water Management District's Lake Okeechobee Pilot Project. Permitting is extremely stringent due to the regulatory criteria that must be met and may cause projects such as these to be cost prohibitive.

As seen in Table I-4, minimal permitting is required for treated water ASR projects. This type of ASR project is becoming more prevalent in Florida. Utilities

TABLE I-4. Permits Required for Treated Water ASR Projects.

Permit Type	Description	Issuing Agency
Well Construction Permit	Treated water ASR must be in accordance with Class V well standards (state Permit)	Florida Department of Environmental Protection
Consumptive Water Use Permit	Permit needed for operation of system, which states quantity of water available for use (state permit)	South Florida Water Management District

TABLE I-5. Permits Required for Untreated Ground Water from one Aquifer to be Injected into Another Aquifer for ASR.

Permit Type	Description	Issuing Agency
Well Construction Permit	Untreated aquifer water for ASR must be in accordance with Class I well standards (state permit)	Florida Department of Environmental Regulation
Water Quality Criteria Exemption	Exemption needed if untreated aquifer water for ASR does not meet primary drinking water standards (state permit)	Florida Department of Environmental Protection
Aquifer Exemption	Exemption needed if injected waters are nonpotable and the aquifer is classified as an underground source of drinking water (federal permit)	United States Environmental Protection Agency
Consumptive Water Use Permit	Permit needed when pumping water from one aquifer to another (state permit)	South Florida Water Management District

may find this alternative useful for meeting seasonal and daily peak demands and future water needs as the population increases.

In 1975, a permit was issued for an aquifer-to-aquifer untreated water ASR pilot project at the Miami Dade Water and Sewer Authority Hialeah Water Treatment Plant. Permitting requirements have become more stringent since the Hialeah project was conducted. An aquifer exemption is now required for aquifer-to-aquifer untreated water ASR projects. Currently this exemption is difficult to obtain since regulating authorities categorize aquifer-to-aquifer ASR as a nonpotable source of water being injected into an underground source of drinking water. The costs of construction and operation of aquifer-to-aquifer ASR facilities designed to meet the more stringent regulatory criteria may be prohibitive.

Existing ASR Facilities

Manatee County. In 1978, Manatee County began treated water ASR investigations in cooperation with the Southwest Florida Water Management District (SWFWMD) and CH2M Hill Engineers. This program start up was a direct result of a 1976 CH2M Hill project for Naples, Florida which included two shallow connector wells that recharged the local production zone by gravity from the overlying water table.

The Manatee County Utilities Department has a surface water treatment plant that operates at 54 MGD adjacent to Lake Manatee, which is an impoundment on the Manatee River. An investigation of an artesian limestone aquifer beneath Lake Manatee was conducted which evaluated aquifer hydraulic characteristics such as transmissivity, storativity and leakance. After a series of injection and recovery tests were conducted to determine water quality and percent of water recovered, it was concluded that Manatee County could meet peak water demands as high as 70 MGD without expanding their water treatment plant. The ASR facility is currently in operation, with a rated storage capacity of 316 million gallons. At the end of 1993, 294 million gallons were in storage in the aquifer (phone conversation January 6, 1994 with Bruce McCloud, Manatee County Utilities, Bradenton, FL.).

Peace River. A 12 MGD surface water treatment plant built by General Development Utilities, Inc. (GDU) supplies water to Port Charlotte. Port Charlotte's source of raw water is the Peace River (now owned and operated by the Peace River/Manasota Regional Water Supply Authority). Due to variations in both water flow and water quality of the river, including occasional movement of saltwater upstream of the plant intake, a 1,920 acre-foot capacity offstream reservoir was constructed for raw water storage. In 1984, GDU was faced with the need to expand their water storage capacity, and as a result, treated water ASR was examined as a potentially less expensive storage option. Two potential production zones were tested to determine if treated water ASR was feasible. Six ASR wells were installed which provide a treated water expansion of 4.9 MGD. Three additional wells are planned for feasibility testing in 1994 (phone conversation January 6, 1994 with Grady Sorah, Peace River/Manasota Regional Water Supply Authority, Port Charlotte, FL.). Over the next 30 years, ASR is expected to reduce capital investment for water supply and treatment facilities for the Peace River by over 50 percent.

Cocoa. The Floridan Aquifer System (FAS) is the source of well water for the Cocoa service area. The wells are located inland as far as 50 miles from some locations in the service area. This great distance is due to saltwater intrusion which is occurring along the coast. The Claude H. Dyal water treatment plant has a capacity of 40 MGD. In 1987 demand had reached 37 MGD, which prompted the City of Cocoa to investigate the potential for treated water ASR as an alternative to water treatment plant expansion.

The success of this test program allowed Cocoa to proceed with treated water ASR and defer a water treatment plant expansion. The system was permitted in 1991 and presently operates at a maximum permitted recovery rate of 8 MGD, utilizing 6 ASR wells (phone conversation January 6, 1994 with Glenn Loeffler, Claude Dyal Water Treatment Plant, Cocoa, FL). Present indications are that plant expansion can be deferred until maximum day demand reaches 50 MGD, but an expansion of raw water supply will be necessary to sustain increases in average withdrawals.

Port Malabar. In 1987, the Palm Bay Utility Corporation at Port Malabar began treated water ASR investigations. The Port Malabar development is within the city limits of Palm Bay on the east coast of Florida and obtains its water supply from an intermediate aquifer. At the time the ASR investigation began, water demands were approaching the water treatment plant capacity of 6 MGD and were, at times, equal to wellfield supply capacity. If the treated water ASR project investigation proved successful, it would help Port Malabar meet its upcoming seasonal and daily peak demands and defer water treatment plant expansion.

A test facility was constructed within the Port Malabar distribution system. This location enabled the recovered water to be put directly into a nearby transmission main. The treated water ASR facility was tested and the recovered water met all drinking water standards and required no retreatment other than disinfection. Today, the Port Malabar ASR facility is fully operational and provides an additional 1 MGD of treated water supply during peak demand months.

Boynton Beach. In late 1992, the city of Boynton Beach began testing of its ASR facility. During the wet season, treated ground water from the Surficial Aquifer System is pumped into the upper portion of the Floridan Aquifer System for storage. Upon recovery, the water is filtered and rechlorinated, then used to augment the public water supply during dry periods and during peak demands. This serves to alleviate stress on the Surficial Aquifer System which is susceptible to saltwater intrusion.

During a dry spell in May 1993, about 17 million gallons of water were recovered from the ASR system. The single ASR well can provide 2,000 GPM of recovered water, although the city is still gathering information. As of early 1994, five injection/storage/recovery cycles had been completed (phone conversation January 6, 1994 with Peter Mazzotti, City of Boynton Beach Utilities, Boynton Beach, FL.).